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THE EFFECTS OF STRESS ON STATE ANXIETY IN AIR TRAFFIC CONTROLLE--ETC(U)
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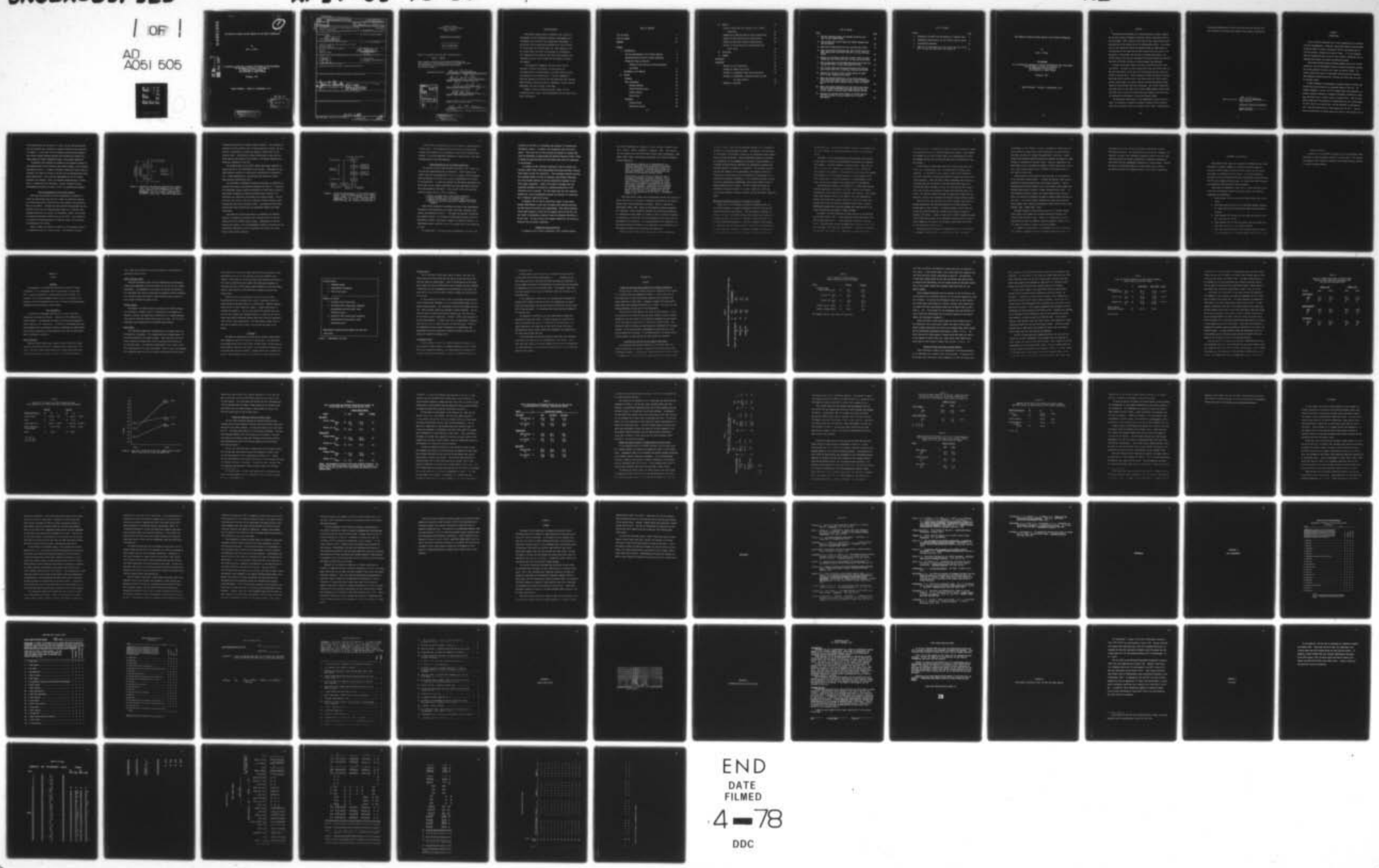

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THE EFFECTS OF STRESS ON STATE ANXIETY IN AIR TRAFFIC CONTROLLERS

by

Neil S. Hibler

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
the Department of Psychology in
the University of South Florida

December, 1977

Major Professor: Charles D. Spielberger, Ph.D.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

14

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
A FIT-CI-78-30

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

9 Doctoral thesis.

4. TITLE (and Subtitle)
6 The Effects of Stress on State Anxiety in Air Traffic Controllers.

5. TYPE OF REPORT & PERIOD COVERED
Dissertation

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
16
Captain Neil S. Hibler

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
AFIT/CI Student at the University of South Florida, Tampa FL

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
AFIT/CI
WPAFB OH 45433

12. REPORT DATE
11 December 1977

13. NUMBER OF PAGES
78 Pages

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
12 89p.

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES
APPROVED FOR PUBLIC RELEASE AFR 190-17.

For James E. Skarsten MSgt USAF
Deputy Director of Information

~~JERRAL F. GUESS, Captain, USAF~~
~~Director of Information, AFIT~~

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Ø12200

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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University of South Florida
Tampa, Florida

CERTIFICATE OF APPROVAL

PH.D. DISSERTATION

This is to certify that the Ph.D. Dissertation of

NEIL S. HIBLER

with a major in Clinical and Community Psychology has been approved by the Examining Committee on August 18, 1977 as satisfactory for the dissertation requirement for the Ph.D. degree.

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ACKNOWLEDGEMENTS

Most genuine appreciation is extended to Dr. Charles D. Spielberger for his continuing direction, encouragement and commitment to my scientific and professional development. I would also like to express my gratitude to Dr. Susan Filskov, Dr. Miles Hardy, Dr. Herbert Meyer, Dr. David VanDercar, and Dr. Harold Vetter for their contributions in strengthening this study by caring enough to share their high standards for research, and to Dr. Chris Tsokos for his generous interest and support.

I am especially indebted to the air traffic control personnel at MacDill and Tyndall Air Force Bases who volunteered their time and energy to a project which was without precedent in our armed forces. I am also indebted to Detective Sergeant William Carlisle and Detectives John Long and Ralph Pflieger, officers of the St. Petersburg, Florida, Police Department, for their ratings of PSE data.

Finally, I wish to recognize my wife, Peggy, for her unrelenting faith, support and encouragement that have made wishes become achievement.

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THE EFFECTS OF STRESS ON STATE ANXIETY IN AIR TRAFFIC CONTROLLERS

by

Neil S. Hibler

An Abstract

Of a dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in
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the University of South Florida

December, 1977

Major Professor: Charles D. Spielberger, Ph.D.

ABSTRACT

The effects of perceived shift difficulty and air traffic density on the state anxiety (A-State) of USAF air traffic controllers (ATC's) were evaluated. ATC's rated the difficulty of day, swing and mid shift work periods at the middle and end of selected work shifts. The A-Trait Scale of the State-Trait Anxiety Inventory (STAI) was administered at the beginning of the study and the STAI A-State Scale was given at the beginning, at the middle, and the end of selected work shifts. Air traffic density (TD) was also recorded for the work periods during which the shift difficulty ratings and anxiety measure were obtained.

A-State levels were found to be higher on difficult shifts than easy shifts. Increases in state anxiety over time were found within the day and swing shifts, while levels of A-State were low and relatively stable in the mid shift. While estimates of shift difficulty indicated that high traffic density shifts were harder than low traffic density shifts, surprisingly, low traffic density work periods aroused higher levels of state anxiety than high TD periods. Air traffic controllers with high scores on the STAI A-Trait scale showed higher A-State levels than ATC's low in A-Trait on shifts that were rated as more difficult, as predicted by Spielberger's State-Trait Anxiety Theory.

An exploratory application of the Psychological Stress Evaluator (PSE), an electronic instrument designed to measure stress reactions from voice recordings, was also included in this study. Unfortunately,

unexpected methodological difficulties restricted the PSE data that were available for analysis and rendered these results inconclusive.

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August 18, 1977
Date of Approval

Chapter I

INTRODUCTION

The air traffic controller has a vital responsibility in facilitating air transportation. Annually, some 26,000 Federal Aviation Administration (FAA) air traffic controllers (ATC's) orchestrate over 58 million takeoffs, landings and enroute flights. It is also apparent that the responsibilities of the ATC have created a profession that is abundant with subtle, yet potent occupational hazards.

Job related stresses present intense demands upon the air traffic controller, and the detrimental effects of these occupational stresses may create potential problems with regard to aviation safety. Air traffic controllers appear to experience intense emotional reactions that sometime interfere with their carrying out duties that are vital to inflight safety.

A high incidence of psychosomatic illnesses among air traffic controllers has been related to the stressful nature of the job. For example, Dougherty, Trites, and Dille (1965) found that controllers reported a greater frequency of symptoms of headache, indigestion, chest pain and ulcers than a control group of private pilots. Cobb and Rose (1973) found that the prevalence of hypertension was four times greater for ATC's than for private pilots, and the incidence of hypertension over a one-year period was six times greater for the ATC's. The incidence and prevalence for peptic ulcers was twice as great among ATC's as

for private pilots and the onset of symptoms in the controllers occurred at an earlier age, especially at airport facilities with high traffic density. On the basis of these findings, Cobb and Rose concluded that stress related diseases occurred with substantially greater frequency among air traffic controllers than in the general population.

The present study examines the effects of two potential sources of job-related stress, shift difficulty and traffic density, on the anxiety experienced by ATC's. In order to provide a broad theoretical frame of reference, the impact of stress on the ATC will be considered from three major perspectives. First, the job requirements of the air traffic controller are examined. Next, the personal characteristics of individuals who become ATC's are discussed. Finally, research that has investigated the effects of stress on ATC's is reviewed and evaluated.

The Job Requirements of Air Traffic Control

What does the controller do that is apparently so stressful? A simple job description would include a number of activities subsumed under the general goal of providing for safe, orderly, and expeditious flow of air traffic. Kirchner and Laurig (1971) have described the controller's role in the air transportation system as a "steering" task. Although remote from the vehicle, the controller "steers" the aircraft by carefully administered instructions to the pilot. Each instruction is a precisely formulated response to both the status of the aircraft and standards for air safety.

Figure 1 depits the interchange within the air transport system of ATC instructions and pilot confirmations. The controller receives

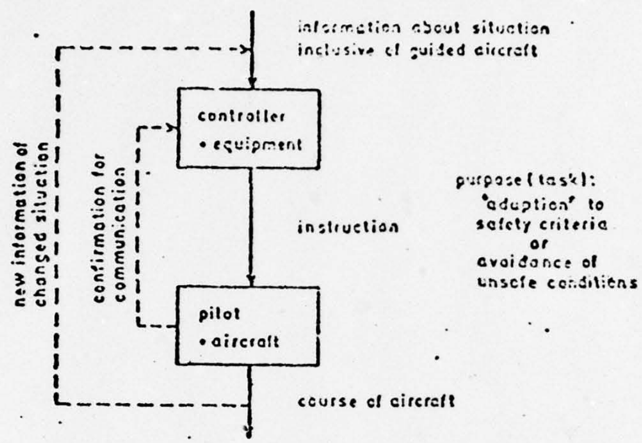

Figure 1. Guidance of aircraft from the ground as a steering task. (From "The Human Operator in Air Traffic Control Systems" by J. H. Kirchner and W. Laurig, Ergonomics, 1971, 14, 549-556. Copyright 1971 by Taylor & Francis Ltd. Reprinted by permission.)

information regarding the aircraft flight situation. This situation is compared to safety criteria, and if unsafe conditions require the controller's intervention, he gives the necessary instructions to the aircraft pilot. Confirmation of these instructions is made, and the pilot corrects the course of his aircraft. The changed situation provides new information to the ATC.

The hardward used in air traffic control has become essential to support the ATC in the fulfillment of his mission. Technology has provided improved channels for information transmission and conformation (e.g., radio communications, computerized data storage and recall, radar position confirmation, etc.).

The controller's information processing functions, as specified by Kirchner and Laurig, are graphically presented in Figure 2. As successful performance requires constant evaluation of flight data in terms of both safety standards and alternative instructions to pilots, the controller must coordinate situational and corrected actions. The aircraft data with which an ATC must be familiar include altitude, speed, distance and fuel levels (Bisseret, 1971). The sources of these data eminate from pilot confirmations and situational updates from other controllers.

The number of aircraft processed at a particular time (traffic density) is generally considered to be a critical factor in the functioning of the air traffic control system. Augmentation of traffic density, for example, would correspondingly enlarge the demands upon the controller's abilities so that the potential for fatigue and stress effects would rapidly increase.

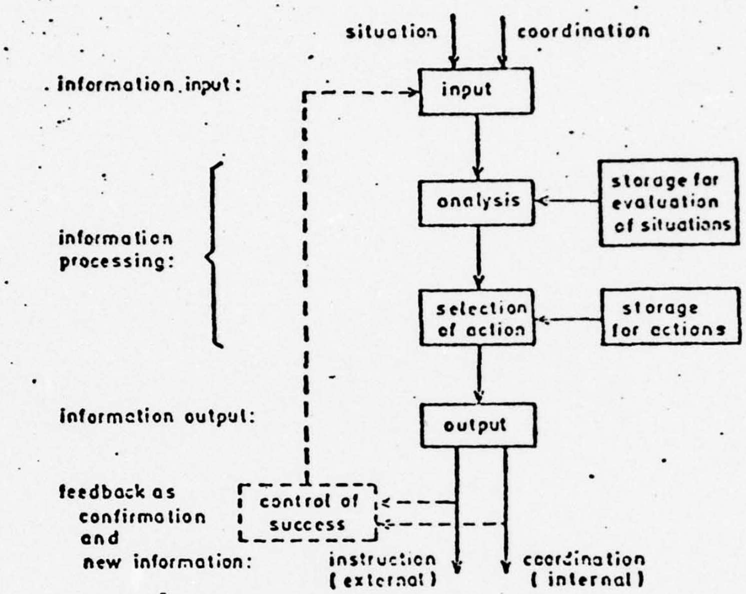

Figure 2. Information processing by the air traffic control system. (From "The Human Operator in Air Traffic Control Systems" by J. H. Kirchner and W. Laurig, Ergonomics, 1971, 14, 549-556. Copyright 1971 by Taylor & Francis Ltd. Reprinted by permission.)

Hopkin (1970) has noted that ATC's are required to provide service 24 hours daily. This demand results in work-shift scheduling which imposes large variations in the quantity of work within different work periods. To maintain equitable allocations of these duties, work shift rotation patterns have been employed.

Characteristics of the Air Traffic Controller

The critical analytic and evaluative functions in air traffic control are the responsibility of the controller. After reviewing the complex tasks and responsibilities of the ATC, Rohmert (1971) concluded that the analysis of the ATC task should be subordinated to the study of the controller. As would be expected from the demand characteristics of his job, the air traffic controller must have many special intellectual and personality attributes. These special skills have been described by Corson (1970, p. iii) as including:

> A highly developed capacity for spatial perception
> A keenly developed, quick and retentive memory
> A capacity for articulate and decisive voice communication
> A capacity for rapid decision making, combined with mature judgment.

Smith (1974) conducted a comprehensive review of the psychological literature on the personality, aptitudes, abilities, interests, motivations, and attributes of ATC's. With regard to aptitude, controllers have superior ability, as reflected in performance measures of spatial orientation, spatial visualization, memory, and numerical ability. On intelligence tests, controllers score in the upper 20% of the population at large.

The examination of ATC personality characteristics has been based

primarily on the 16PF, an instrument that measures 16 characteristic personality factors. In general, FAA controllers tend to be quite normal. They score low in trait anxiety and respond in a manner that could be considered as tough-minded and decisive (Karson & O'Dell, 1974). It should be noted that many FAA controllers have prior ATC experience in the military.

In research on the vocational interests of the air traffic controllers, Smith (1974; 1975) administered the Strong Vocational Interest Blank (SVIB) to male FAA controllers. This instrument examines opinions and attitudes toward a variety of subjects, and provides comparisons with the interest patterns of persons successfully employed in over fifty career categories. Smith's SVIB results indicated that the vocational interests of controllers conformed essentially to the interests of men in general. The only trend away from this normative pattern was a high correspondence between the interests of controllers and a "technical supervision" group.

In summary, FAA air traffic controllers appear to have above average intelligence, a high level of spatial and abstract abilities, and they tend to be decisive and tough-minded. While these characteristics seem essential to carry out the complex duties of the ATC, the job itself is nevertheless stressful, even for personnel qualified to do this work. The next section will examine research on the effects of stress on the air traffic controller.

Effects of Stress on the ATC

In research on air traffic controllers, shift rotation patterns

have been investigated as a source of stress, (Melton, McKenzie, Smith, Polis, Higgins, Hoffman, Funkhouser & Saldivar, 1973). The framework for this research has been Trait-State Anxiety Theory (Spielberger, 1966, 1972a, 1972b, 1975), which posits two related, yet logically different anxiety constructs:

> State anxiety (A-State) may be conceptualized as a transitory emotional state or condition of the human organism that varies in intensity and fluctuates over time. This condition is characterized by subjective, perceived feelings of tension and apprehension, and activation of the Autonomic Nervous System.
>
> Trait Anxiety (A-Trait) refers to relatively stable individual differences in anxiety proneness, that is to differences in the disposition to perceive a wide range of stimulus situations as dangerous or threatening, and in the tendency to respond to such threats with A-state reactions. A-trait may also be regarded as reflecting individual differences in the frequency and the intensity with which A-states have been manifested in the past and in the probability that such states will be experienced in the future. (Spielberger, 1972a, p. 39).

Trait-State Anxiety Theory also distinguishes between the concepts of stress and threat in providing an integrated explanation of the process through which A-State reactions are evoked. Stress, as defined by Spielberger (1972a; 1975) refers to the objective stimulus properties of a situation. While stressful situations are perceived as dangerous or threatening by most people, the manner in which a stressful situation is appraised by a particular individual depends upon his own subjective assessment of the situation. For reasons peculiar to an individual, an objectively stressful situation may be appraised as non-threatening or a nonstressful situation may be appraised as threatening.

While the term "stress" refers to objective stimulus conditions,

the term "threat" refers to the subjective appraisal of a situation as physically or psychologically dangerous. The appraisal of a situation as threatening is determined, in part, by the individual's prior experience in similar situations. When an individual perceives a situation as threatening, he will experience an increase in state anxiety, i.e., emotional and physiological reactions are experienced by persons who interpret specific situations as threatening. The intensity and duration of this reaction will be determined by the amount of personal threat that is perceived and by the duration of the appraisal of the situation as personally threatening. The State-Trait Anxiety Inventory (STAI) was constructed by Spielberger, Gorsuch and Lushene (1970) to measure State and Trait Anxiety. The STAI A-State Scale asks the individual to respond to items as he feels "right now," while the A-Trait Scale requires responses regarding how the individual "generally" feels.

Effects of Work Shifts and Shift Difficulty on Anxiety

Melton et al. (1973) examined the stresses associated with two work shift schedules on several psychological, physiological and biochemical indices of state anxiety. This investigation compared the effects of a 2-2-1 work shift rotation which consists of a sequence of 2 evening or swing shifts (4 PM to midnight), 2 day shifts (8 AM to 4PM) and 1 mid shift (midnight to 8 AM) with a straight 5-day pattern (5 consecutive days on the same shift). When given the opportunity to determine their work patterns, controllers expressed a preference for the 2-2-1 schedule because of the extended time off that this shift

pattern provided. Supervisory personnel, however, were concerned that the 2-2-1 rotation did not provide sufficient time for rest between shifts.

The effect of both shift patterns on state anxiety were examined at the same ATC facility by conducting the study during two separate time periods. The 5-day rotation was studied first. Then, one year later, the 2-2-1 shift pattern was implemented and its effects on state anxiety were examined. The stress effects of these shift patterns were measured by urine and blood specimens, and by responses to the STAI A-State Scale. Of the 19 controllers who participated in this study, 12 served as subjects in both phases of the investigation.

The biochemical results in the Melton et al. (1973) study were not entirely consistent, but scores on the STAI A-State scale increased significantly within each of the three work shift periods. STAI A-State levels were highest during the mid shifts, which was considered to reflect with controllers reported dislike of work during these shift periods rather than air traffic conditions (Smith, 1973). However, differences between shift rotation patterns were concluded to be too slight to indicate superiority of either schedule.

The effects of shift difficulty on state anxiety was investigated by Smith and Melton (1974). Eighty controllers were administered the STAI A-State Scale before and after each work shift over a four-day period. The difficulty of each completed shift was rated by the ATC's on a five-point Shift Difficulty Scale (SDS). A score of 1 on the SDS indicated an "easy" shift while a score of 5 was assigned to "very

difficult" shifts. The effects of A-Trait and shift difficulty on state anxiety were examined in a factorial experimental design. Each subject contributed only one STAI A-State Score, which corresponded to either an extremely difficult or an extremely easy shift as determined by the SDS ratings.

In the Smith and Melton study mean STAI A-Trait scores were relatively low, corresponding to the 31st percentile for college undergraduates. The pre-shift A-State scores of high A-Trait controllers were lower than their A-Trait scores, while the reverse was true for low A-Trait subjects. Smith and Melton (1974) interpreted this finding as indicating that the initiation of work distracted high A-Trait controllers from other anxieties, whereas low trait anxious ATC's experienced more arousal and anticipatory stress when initiating their work shifts. All subjects showed increases in A-State during both easy and difficult shifts; these increases were greater during difficult shifts.

Smith and Melton concluded that air traffic control work generally arouses anxiety and that the controllers' level of state anxiety increased even on "easy" shifts. It should be noted, however, that the effects of shift difficulty on A-State in this study were based on subjects' SDS ratings. Future research on air traffic controllers would benefit from more objective shift difficulty measures based on quantitative indices of air traffic density such as the number of aircraft handled by the ATC during a shift.

Since questionnaire measures are easily faked and may be responded to carelessly, physiological measures of anxiety have been used as

alternatives to self reports. However, physiological indices have not proven effective measures of A-State fluctuations, and such measures are often intrusive and disrupt the controllers' activities. Recent research has examined promising objective procedures for measuring state anxiety in recordings of the human voice. Since all controllers' communications are tape recorded and measures of voice quality are unobtrusive, such measures appear to have potential for assessing stress in air traffic control work.

Three methods of voice analysis have been used in the assessment of ATC and pilot communications. Williams and Stevens (1969) spectrographically analyzed spoken words into frequency patterns. Another method examined vertical deflections of vowel sounds within graphically recorded spectrograms (Kuroda, Fujiwara, Okamura & Utsuki, 1976). The most promising technique employs the Psychological Stress Evaluator (PSE), an electronic instrument designed to examine stress reflected in the voice. This device filters recorded voice input and transforms these signals into a graphic presentation or chart which is then scored (Dektor, 1972; Planar Corp., 1972).

Although research on the validity of the PSE is limited, Greaner (1976) found a high degree of agreement between PSE ratings, STAI A-State scores and heart rate. However, in a second study in which essentially the same experimental method was employed, Hibler (1976) was unable to replicate Greaner's promising findings.

In summary, an evaluation of the literature on stress in air traffic controllers suggests that future research would benefit from the

examination of quantity of work as a specific determinant of shift difficulty and stress. The monitoring of traffic density (frequency of takeoffs, landings, etc.) provides an objective index of the ATC's work load which should be related to controller's subjective estimates of shift difficulty and concomitant fluctuations in state anxiety. Finally, the PSE as an unobtrusive measure of state anxiety appears to be a promising instrument for evaluating stress in air traffic controllers.

STATEMENT OF THE PROBLEM

The purpose of this study was to examine the effects of two stress indicators, subjective ratings of shift difficulty and objective measure of traffic density on level of state anxiety for air traffic controllers who differed in trait anxiety. The rating procedures developed by Smith and Melton (1974) for investigating shift difficulty for ATC's were adapted for this study. An index of air traffic density was constructed from routine ATC traffic records.

Based upon the findings of Melton (et al., 1973) Smith and Melton (1974) and Spielberger's State-Trait Anxiety Theory, the following hypotheses were formulated:

1. State Anxiety will be higher on difficult shifts than on easy shifts.
2. High trait anxious subjects will experience greater increases in state anxiety on difficult shifts than low trait anxious subjects.
3. State Anxiety will increase from the start to the end of the day, swing and mid shifts.
4. State Anxiety will be higher on shifts with high traffic density than on shifts with low traffic density.
5. High trait anxious subjects will experience greater increases in state anxiety on high traffic density shifts than low trait

anxious subjects.

In addition, as an exploratory procedure, the Psychological Stress Evaluator was used to measure A-State in the human voice. PSE ratings were expected to be higher for periods of high traffic density than for low traffic density periods.

Chapter II

METHOD

Subjects

The subjects in this study were 104 male Air Force Air Traffic Controllers (ATC's) assigned to MacDill and Tyndall Air Force Bases (AFB), located respectively in Tampa and Panama City, Florida. The voluntary, fully informed consent of each subject was obtained as required by Air Force Regulation 169-8, and by the Human Subjects Research Committee at the University of South Florida.

Test Instruments

The principle independent variables in this study were trait anxiety and two measures of stress: ratings of shift difficulty and traffic density. The dependent variables were self-report measures of state anxiety and PSE voice prints. In addition, biographical data were also obtained and an experimental measure of sociopathy was administered. Each of these instruments is described below and a copy of each instrument is included in Appendix A.

Anxiety Measures

Trait and state anxiety were measured by the A-Trait and A-State scales of the State-Trait Anxiety Inventory (STAI) (Spielberger et al. 1970). The STAI A-Trait scale consists of 20 items which require the subject to report how he generally feels. The A-State scale consists

of 20 items that instruct the subject to report how he felt during a particular moment in time.

Shift Difficulty Scale

The Shift Difficulty Scale (SDS) was adapted from the five-point rating scale developed by Smith and Melton for use with FAA Air Traffic Controllers. The respondent is instructed to estimate the difficulty of a particular work shift by recording his judgment of shift difficulty on a six-point Likert type scale, ranging from very easy (a score of one) to very difficult (a score of six).

Traffic Density

The measure of traffic density was based on air traffic records which contained a temporal record of information on the frequency of takeoffs, landings, and touch-and-go maneuvers (i.e., landing approach, touch down and take-off without having come to a stop). The ATC shift supervisors were responsible for maintaining these records.

Voice Prints

From routinely recorded ATC communications, the number "zero" was extracted and re-recorded. This response word was employed because it was used frequently in ATC communications. Thus, the word "zero" provided a routine ATC message that could be examined during periods of low and high stress. Six recordings were made of "zero", using a Uher 4000 tape recorder at 7½ inches per second. Three of these were selected from recordings made while the controller simultaneously handled one or

two aircraft (low stress) and three were taken from recordings of communications while the ATC was handling six or more aircraft (high stress). Definitions of the low and high stress criteria were made on the basis of consultation with senior ATC supervisory personnel who indicated that such criteria would provide adequate low and high stress samples, while occurring with sufficient frequency to maximize the subject pool.

Tape recordings were converted to voice prints by a Dektor Psychological Stress Evaluator (PSE), Model 1, operated in Mode III which converted the audio signal to a visual chart. Recorder playback speed was set at 15/16 inches per second. A sample voice print is included in Appendix B. The six voice prints (PSE charts) that were made for each subject were randomly placed in a chart set, and the PSE raters were asked to determine whether each voice print was representative of low or high state anxiety. For each subject, raters were instructed to identify three charts as high stress and three as low stress.

Procedure

The study was conducted on site at the air traffic control facilities located at MacDill and Tyndall Air Force Bases. The controllers were tested during normal work shifts, 24 hours daily, for nine days at MacDill and for seven days at Tyndall. The experimental procedures can be divided into two major periods, a testing period and an observation period. These procedures are outlined in Figure 3 and described below.

Testing Period

1. Informed Consent
2. Biographical Information
3. STAI A-Trait Scale

Observation Period

1. Pre-shift STAI A-State Scale
2. Half-shift STAI A-State Scale (modified instructions) and half shift, shift difficulty scale.*
3. Post-shift STAI A-State Scale (modified instructions) and post-shift, shift difficulty scale.*

*Supervisors recorded traffic density for each half work shift.

Figure 3. Experimental Procedure.

Testing Period

The ATC subjects in this study worked in teams. Each team was tested during the first shift that was worked by the team during the time the study was taking place. Prior to participating in the study, each subject was given an information sheet (Appendix C) that contained a description of the requirements for participation in the study, and asked to sign this sheet to signify informed consent for participating in the study.

At the beginning of the first shift, an envelope which contained a list of instructions (Appendix C) and an identification number was presented to each subject. The instructions informed the subject that the study identification number was assigned to assure anonymity. The subject was asked to provide information regarding age, sex, and amount of air traffic control experience. The STAI A-Trait Scale (Appendix A) was then administered. At Tyndall AFB only, an experimental Sociopathy Scale and the MMPI LIe Scale (Appendix A) were also given. Following the completion of each of these instruments, the controllers were instructed to place the test forms inside the envelope, which was returned to a controlled research file.

Observation Period

At the beginning of each shift state anxiety was measured. For the pre-shift A-State measure, the subject completed the STAI A-State Scale with standard instructions, and then placed the completed STAI Test Form in his research envelope, which was immediately returned to

the controlled file.

Halfway through each work shift, the subject was given the STAI A-State Scale with modified instructions (". . . . .indicate how you felt during the half of the work shift that you have just completed."), and was asked to estimate the difficulty of the work-shift just completed by responding to the Shift Difficulty Scale. The subjects' test forms were then placed in their research envelopes which were returned to the controlled file.

At the conclusion of each shift, the subjects again completed the modified STAI A-State Scale and the SDS, with instructions to report levels of state anxiety and estimates of shift difficulty for the second half of the work shift. The completed test forms were then returned to the research file.

Two measures of traffic density were determined by supervisory personnel for each work shift. The first measure was a count of the number of aircraft handled in the first half of the work shift. The second measure was the count for the last half of each work shift. Tabulations of hourly traffic counts (TD recordings) were conducted at the conclusion of each work day.

At the conclusion of the final shift on which data were collected, each subject was thanked for his participation in the study. He was also told that a copy of the final research results would be provided to the Chief Controller when the study was completed and that he would have access to this report.

Chapter III

RESULTS

Levels of State and Trait Anxiety in Air Traffic Controllers

The age and air traffic control experience reported by the subjects in the present study are presented in Table 1. Most of the ATC's in this study were in their late twenties generally and had about five years experience in their jobs. Subjects at Tyndall AFB were significantly older than subjects at MacDill AFB, t (102) = 2.53, $p < .01$, and had approximately one year more of ATC experience.

The results of this study are set forth in four sections. In the first section, the levels of state and trait anxiety of the air traffic controllers who were tested in this study are compared with two samples of FAA controllers (Melton et al., 1973; Smith & Melton, 1974). The effects of shift difficulty on state anxiety are presented in the second section. In the third section, differences in A-State on day, swing and mid shifts are evaluated. In the final section, the effects of air traffic density on state anxiety and voice prints are reported.

Comparison of USAF and FAA Air Traffic Controllers

The state and trait anxiety score of U.S. Air Force (USAF) air traffic controllers are compared in Table 2 with similar data for FAA controllers reported by Melton et al. (1973) and Smith and Melton (1974). The separate STAI A-Trait and A-State means and standard deviations for

Table 1

Age and Experience Means and Standard Deviations for ATC's in the Present Study

	N	AGE	ATC EXPERIENCE
Present Study (Entire Sample)	104	28.2	5.2
SD		5.9	5.3
MacDill AFB	48	26.6	4.7
SD		6.7	5.8
Tyndall AFB	56	29.4	5.7
SD		4.9	5.0

Table 2

STAI A-State and A-Trait Means for
Present Research and the FAA Studies

Study		N	A-Trait	A-State
Present Study (total sample)	mean	104	31.2	33.5
	SD		7.0	10.1
MacDill AFB:	mean	48	30.3	29.8
	SD		7.1	7.8
Tyndall AFB:	mean	56	32.2	36.5
	SD		6.9	10.4
*Melton, et al. (1973)		19	30.0	33.2
*Smith & Melton (1974)		80	29.6	32.5

*FAA Studies did not report standard deviations

USAF ATC's at MacDill and Tyndall Air Force Bases are also reported in this table. In the present study, STAI A-State means were computed from the first half shift scores contributed by each ATC. The mean STAI A-Trait and A-State scores for the USAF controllers were quite similar to those of FAA controllers, but the A-State scores for the USAF controllers in the Tyndall sample were somewhat higher than those for the MacDill sample.

Since standard deviations were not reported in the FAA studies, the significance of the differences between the FAA and USAF controllers could not be tested. In testing the difference between the two USAF samples, the A-Trait means were found to be similar, whereas, the A-State scores at Tyndall AFB were significantly higher than at MacDill AFB, t (102) = 3.64, p .001. The findings for the Sociopathy Scale and the MMPI Lie Scale, which were administered for exploratory purposes to the Tyndall sample, are discussed in Appendix D.

Smith and Melton (1974) reported that the STAI A-State scores of FAA controllers were significantly higher than their A-Trait scores. Higher A-State scores were also found in the present study (total sample) and this difference approached significance, t (206) = 1.92, p .06. Within the two Air Force samples, A-State scores were about the same as A-Trait scores at MacDill AFB, but A-State scores were significantly higher than A-Trait scores at Tyndall AFB, t (110) = 2.57, p .05.

Effects of Shift Difficulty on State Anxiety

"Shift Difficulty" refers to the controllers' subjective estimates of the difficulty of a specific shift or work period. To measure shift difficulty, Smith and Melton (1974) developed a single-item rating scale

which contained five descriptive points, ranging from very easy to very difficult. The controllers in the Smith and Melton study completed this Shift Difficulty Scale and the STAI A-State scale following each work shift, and subjects were assigned to "easy shift" or "difficult shift" groups on the basis of their most extreme (high or low) ratings.

In the present study, a six-point Shift Difficulty Scale (SDS), similar to the five-point scale developed by Smith and Melton, was employed. By providing an even number of rating points, tendencies to check the mid-point of the scales could be reduced. The SDS and STAI A-State scale were administered half way through each work shift, and at the end of the shift. This procedure permitted the assessment of shift difficulty and state anxiety for half-shift units. Subjects were included in the analyses of shift difficulty only if they reported SDS ratings that varied by at least two points on the SDS scale. These extreme ratings, which defined "easy" and "hard" shifts, were required to ensure adequate separation of the shift difficulty groups. Where the subject reported two or more extreme SDS ratings of equal value, the average STAI A-State score for these shifts was computed.

The STAI A-State means and standard deviations for easy and hard shifts for the USAF controllers in the present study are reported in Table 2 where they are compared with the mean A-State scores for the FAA controllers in the Smith and Melton study. The mean A-State scores for the hard shifts were similar in both studies, whereas the A-State scores for the easy shifts were somewhat lower in the present study, as can be noted in Table 3. The difference in the A-State means between easy

Table 3

Mean STAI A-State Scores and t-test of the Difference Between Easy and Hard Work Shifts

		N	Easy Shift	Hard Shift	t-test
Present Study					
Total Sample	Mean	70	31.16	37.37	6.13***
	SD		7.39	9.72	
MacDill AFB:	Mean	34	30.59	34.69	3.69***
	SD		6.85	8.07	
Tyndall AFB:	Mean	36	31.89	39.90	5.01***
	SD		7.92	10.54	
Smith & Melton (Post Shift Scores)		80	33.10	37.55	

*** $p < .001$

hard shifts for the total sample in the present study was highly significant, as were the differences in A-State levels between easy and hard shifts at both MacDill and Tyndall AFBs. The mean A-State scores for the controllers at these facilities were similar on the easy shifts, but the Tyndall controllers had significantly higher A-State scores on hard shifts than the MacDill controllers, $\underline{t}$ (63) = 2.31, $\underline{p} < .001$.

The effects of shift difficulty on state anxiety for controllers who differed in trait anxiety were examined separately for the controllers at MacDill and Tyndall AFBs. For these analyses, the controllers were divided into three groups approximately equal in size. In both samples, controllers with STAI A-Trait scores equal to or greater than 34 were assigned to the high A-Trait (HA-Trait) group, those who scored 29 to 33 were assigned to the medium A-Trait (MA-Trait) group and subjects who scored 28 or less were in the low A-Trait (LA-Trait) group. Table 4 presents the A-State means and standard deviations of the three A-Trait groups for easy and hard shifts. These data were evaluated in separate 3x2 repeated-measures analyses of variance for the MacDill and Tyndall samples. In these analyses, which are summarized in Table 5, trait anxiety was the between-subjects variable and shift difficulty (easy vs. hard shifts) was the within-subjects variable.

For the MacDill AFB sample, only the shift difficulty main effect was significant ($\underline{p} < .01$), which reflected the fact that A-State scores were higher on hard shifts for all three A-Trait groups. In the Tyndall AFB sample, the Trait Anxiety X Shift Difficulty interaction was significant. This interaction, which is graphically depicted in Figure 4,

Table 4

Means and Standard Deviations for STAI A-State Scores of High, Medium and Low A-Trait USAF ATC's on Easy and Hard Shifts

	MACDILL AFB		TYNDALL AFB	
Groups	Easy	Hard	Easy	Hard
HIGH ANXIETY				
Mean	33.7	35.8	33.3	47.3
SD	9.0	7.7	9.0	10.1
N	13	13	12	12
MEDIUM ANXIETY				
Mean	29.9	31.8	34.9	37.8
SD	3.4	4.8	7.1	7.8
N	9	9	12	12
LOW ANXIETY				
Mean	27.1	35.5	27.0	34.3
SD	4.2	10.2	5.2	9.7
N	12	12	12	12

Table 5

Analysis of Variance of the STAI A-State Scores for
High, Medium and Low A-Trait USAF ATC's on Easy and Hard Shifts

	MacDill			Tyndall		
Source of Variance	df	MS	F	df	MS	F
A-Trait level	2	107.20	1.38	2	566.77	5.36**
error	31	77.84		33	96.79	
Shift Difficulty	1	282.51	9.81**	1	1151.99	27.94***
Shift Difficulty X A-Trait level	2	79.97	2.78	2	186.79	4.53*
error	31	28.79		33	41.22	

* $p. < .5$
** $p. < .01$
*** $p. < .001$

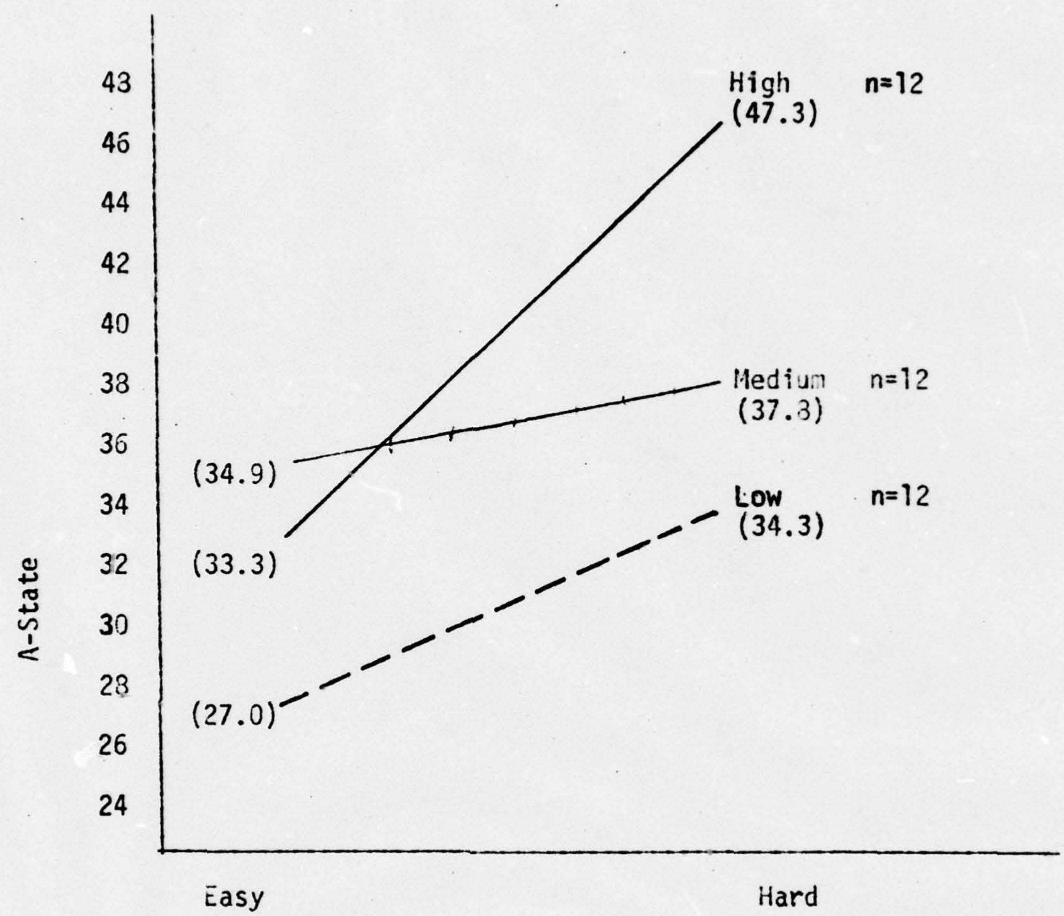

Figure 4. Mean STAI A-State Scores for high, medium and low A-Trait ATC's in easy and hard shifts at Tyndall AFB

seemed to be due primarily to a greater increase in A-State from the easy to the hard shifts for the HA-Trait group than for the LA- and MA-Trait groups. The significant main effects of shift difficulty and A-Trait resulted from the higher A-State scores for all groups on the hard shifts, and the higher average A-State scores for the HA- and MA-Trait groups than for the LA-Trait group.

Effects of Daily Work Shifts on State Anxiety

The work shift schedules employed to maintain round-the-clock coverage at air traffic control facilities typically utilize three shift periods of eight hours duration. The day shift begins at 8 AM and ends at 4 PM. The swing shift begins at 4 PM and ends at midnight. The work shift between midnight and 8 AM is known as the mid shift. The work shift data in the present study were limited to the Tyndall sample because scheduling at MacDill AFB did not conform to the traditional three-shift pattern.[1]

The pre- and post-shift STAI A-State means for the Tyndall controllers for the day, swing and mid shifts are compared in Table 6 with similar data reported for FAA controllers by Melton et al., (1973). Standard deviations are also reported for the Air Force subjects but were not available for the FAA subjects. It should be noted, however, that the procedures for measuring A-State in these studies were slightly

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[1]At MacDill, there were four work shifts per 24-hour period, and these were not comparable to the eight-hour shifts employed at Tyndall and at most FAA facilities.

Table 6

STAI A-State Means and Standard Deviations and t-Tests for FAA and USAF ATC's in Day, Swing and Mid Shifts

Shift		N	Within Shift Period: Pre	Post*	t-tests
Day Shift					
Present Study	Mean	22	30.1	35.4	.02
	SD		6.8	9.0	
Melton, et. al.	Mean	19	30.6	34.9	.05
Swing Shift					
Present Study	Mean	18	32.5	36.9	.02
	SD		7.09	10.69	
Melton, et. al.	Mean	19	31.5	33.9	.05
Mid Shift					
Present Study	Mean	9	29.4	30.4	NS
	SD		5.8	6.02	
Melton, et. al.	Mean	19	32.1	36.2	.05

*Note: The procedures in these studies were slightly different. Pre and Post Shift STAI A-State means are reported for the Melton et. al. study, and pre and last half shift mean scores are reported for the present study.

different. The pre-shift measures were essentially the same in both studies, but one post-shift STAI A-State means in the Melton et al. study required subjects to report how they felt after the shift was completed while in the present study the post-shift measure asked subjects to report how they felt during the last half of the shift.

The day shift A-State scores in the Melton et al. study and the present study were quite similar. For the swing shift, pre-shift A-State scores were similar in the two studies, and the A-State scores increased significantly for both USAF and FAA controllers. For the mid shift, controllers in the present study were initially lower in A-State and remained low throughout this shift while their FAA counterparts increased in A-State from pre to post shift. Thus, significant increases in A-State level occurred in the day and swing shifts in the present study but not in the mid shift, while FAA controllers increased significantly in A-State all three work shifts.

In order to examine the effects of work shifts on state anxiety for subjects who differed in trait anxiety, the subjects for each shift were divided into high (HA) and low (LA) A-Trait groups that were as nearly equal in numbers as possible. The HA-Trait group consisted of subjects whose STAI A-Trait scores were 32 or greater; the LA-Trait group was comprised of subjects with A-Trait scores of 31 or less. The STAI A-State means and standard deviation for the HA- and LA-Trait groups for the Day, Swing and Mid Shifts are presented in Table 7. The data for each shift were evaluated in separate 2 x 3 repeated-measures analyses of variance in which Trait Anxiety (HA vs. LA) was the between-

Table 7

STAI A-State Means and Standard Deviations for High and Low A-Trait USAF ATC's in the Day, Swing and Mid Shifts

SHIFT	N	WITHIN SHIFT PERIOD		
DAY SHIFT		Pre	1st Half	2nd Half
High A-Trait	13	33.5	35.9	37.9
SD		7.4	8.9	7.6
Low A-Trait	9	26.7	30.8	32.4
SD		2.9	4.0	10.4
SWING SHIFT				
High A-Trait	9	34.3	39.1	40.1
SD		6.5	10.1	10.5
Low A-Trait	9	30.7	31.1	33.7
SD		7.5	6.9	10.2
MID SHIFT				
High A-Trait	5	29.0	29.6	31.0
SD		17.5	16.7	17.7
Low A-Trait	4	29.8	29.5	29.8
SD		2.8	2.5	3.9

subjects variable and shift periods (pre vs. 1st half vs. 2nd half) was the within-subjects variable.

The results of the analyses of the A-State data for each shift are presented in Table 8. For the day shift, the main effect for trait anxiety, was significant indication that the HA-Trait subjects were consistantly higher in A-State than the LA-Trait subjects. In addition, the main effect for periods approached significance ($p < .06$), reflecting the tendency for A-State scores to increase over time. The periods effect was also significant in the Swing Shift again reflecting the increase in A-State over time. While the A-State scores of HA-Trait subjects were consistantly higher than those of LA-Trait subjects in the swing shift, these differences were not statistically significant During the mid shift, A-State scores were low and relatively stable for both HA- and LA-Trait subjects.

Effects of Traffic Density on State Anxiety and Voice Prints

On the assumption that an increased workload would be more stressful, traffic density (TD) provided an objective measure of shift difficulty. Information about TD was obtained from routine records maintained by air traffic control supervisory personnel. TD was defined operationally in terms of the number of aircraft processed by a controller during a particular half-shift period. It was expected that higher TD would be more stressful and contribute to higher A-State levels.

The effects of traffic density on state anxiety were investigated by examining the STAI A-State scores that corresponded to work shifts with the highest and lowest TD counts for the 36 Tyndall AFB ATC's who

Table 8

Analysis of Variance of STAI A-State Scores for
USAF ATC's in Day, Swing and Mid Shifts

	Day			Swing			Mid		
Scores of Variance	df	MS	F	df	MS	F	df	MS	F
A-Trait level	1	537.86	7.11*	1	492.00	2.48	1	0.27	.00
error	20	75.63		16	198.76		7	512.25	
Period	2	138.98	2.99	2	87.72	5.39**	2	2.54	.39
Period X A-Trait level	2	4.62	.09	2	21.68	1.33	2	2.24	.34
error	40			32	16.27		14		

* p. .05
** p. .01

contributed data to shift difficulty analysis. The highest TD counts for these subjects ranged from 80 to 750 aircraft with a median of 111.2. The lowest TD counts ranged from 0 to 215, with a median of 24.5.

The A-State Scores for each subject that corresponded with his work shift with the highest and lowest air traffic density are reported in Table 9. Surprisingly, the STAI A-State mean score was higher during low traffic density periods than for high TD shifts, and this difference was highly significant, $\underline{t}$ (35) = 6.54, $\underline{p} < .001$. Mean shift difficulty scores for each subjects' lowest and highest TD shifts are also included in Table 9. As expected, shift difficulty was rated significantly higher, $\underline{t}$ (35) = 2.96, $\underline{p} < .01$, during high TD periods than for the low TD periods.

The mean A-State scores for high and low TD shifts for the high, medium and low A-Trait groups are presented in Table 10. In this analysis the same STAI A-Trait cut off scores were used in defining the anxiety groups as in the shift difficulty analysis. The effects of TD and A-Trait on state anxiety were evaluated in a 3X2 repeated-measurses analysis of variance in which trait anxiety was the between-subjects variable and traffic density was the within-subjects variable. The results of this analysis are reported in Table 11. Only the main effect of A-Trait was significant, indicating consistantly higher A-State scores for the HA- and MA-Trait groups in both low and high TD periods, as may be noted in Table 10. The traffic density main effects also approached significance, $\underline{p} < .10$, reflecting a tendency for the

Table 9
Means and Standard Deviations of the STAI A-State and Shift Difficulty Scale Scores for Air Traffic Controllers on Low and High Traffic Density Shifts (N=36) at Tyndall AFB

	TRAFFIC DENSITY Low	High	t
STAI A-State			
Mean	35.8	33.1	6.64**
SD	10.0	8.0	
Shift Difficulty			
Mean	2.5	3.4	2.96*
SD	1.4	1.5	

* $p < .01$
** $p < .001$

Table 10

Means and Standard Deviations of the STAI A-State Scores for Air Traffic Controllers with High, Medium, and Low A-Trait Scores in Low and High Traffic Density Periods

Group	N	TRAFFIC DENSITY Low	High
High A-Trait	12		
MEAN		41.1	34.9
SD		10.6	9.6
Medium A-Trait	12		
MEAN		37.0	35.9
SD		8.0	7.2
Low A-Trait	12		
MEAN		29.0	28.4
SD		7.5	5.4

Table 11

Analysis of Variance of the Effects of Traffic Density and Trait Anxiety on State Anxiety for Air Traffic Controllers

Source of Variance	df	MS	F
A-Trait	2	583.78	6.48*
error	33	90.03	
Traffic Density	1	128.00	2.83
Traffic Density X A-Trait	2	55.29	1.22
error	33	45.23	

* p. $<$ .01

controllers to have higher A-State levels in periods of low traffic density, especially the subjects in the HA-Trait group.

In order to examine the effects of traffic density on voice prints, it was necessary to have precise information on air traffic handled by each controller. Such information was available only at the Tyndall radar control (RAPCON) office. Master recordings were routinely made for all ATC messages. Magnetic recordings of ATC communications were re-recorded for shifts during which controllers simultaneously handled either one or two aircraft (low TD), or six or more aircraft (high TD).

Unfortunately, several factors diminished the utility of the voice print data. Of the 32 subjects at the Tyndall RAPCON, eight were lost from voice print analyses because they did not meet the criteria of high and low TD (stress). Ten additional subjects were lost because background noise and the subjects' accelerated speech rate made their voice prints unacceptable. During high traffic density periods, these subjects did not pause between words, which provided insufficient word separation for function of the Psychological Stress Evaluator (PSE).

The voice prints for the remaining 14 subjects were scored for low or high stress by three trained PSE raters.[1] Agreement among the scores assigned by these raters was quite low: the percentage of agreement between pairs of raters were only 55%, 58% and 74%. Given this lack of

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[1]The three raters were officers of the Homicide Division of the St. Petersburg, Florida, Police Department. All of the raters were trained by the Dektor Corp., manufacturer of the Psychological Stress Evaluator.

agreement among raters, and the fact that voice print data were available for only slightly more than 10% of the total sample of controllers, further analyses of voice prints were considered meaningless.

DISCUSSION

In this study, the scores of United States Air Force (USAF) air traffic controllers on the State-Trait Anxiety Inventory (STAI) were found to be similar to the scores on these scales previously reported for Federal Aviation Administration (FAA) controllers. On work shifts rated as most difficult by the USAF controllers, state anxiety scores were significantly higher than on shifts which were rated as lower in difficulty. These findings are in general accord with Hypothesis 1 of the present study, which predicted that A-State would be higher on difficult shifts, and they are consistent with results reported for FAA controllers by Smith and Melton (1974).

While there were no differential changes in state anxiety for high and low A-Trait ATC's at MacDill AFB, the high trait anxious controllers at Tyndall AFB showed greater increases in state anxiety from easy to difficult shifts than did Tyndall controllers who were low in A-Trait. Thus, the findings for the Tyndall AFB controllers supported Hypothesis 2 of the present study. Based on Spielberger's (1966, 1972a, 1972b, 1975) State-Trait Anxiety Theory, this hypothesis predicted that the high A-Trait controllers would show greater increases in state anxiety when working difficult shifts than would ATC's who were low in A-Trait.

State anxiety levels increased during the course of the day and swing shifts in the present study, while remaining low and essentially unchanged throughout the mid shift. These findings provided partial

support for Hypothesis 3, which predicted that A-State would increase over time during all three shifts. Melton et al.(1973) found that state anxiety increased for FAA air traffic controllers during all three shifts, and that increases within the mid shift were greater than for any other shift, presumably because pilots are more dependent on controllers when taking off and landing in the dark. The failure to find any increase in state anxiety in the mid shift of the present study may be attributed to the fact that the USAF controllers handled very few aircraft during this shift, and sometimes none at all.

In the design of the present study, it was assumed that traffic density (TD), i.e., the number of aircraft handled during a particular work shift, would provide an objective measure of shift difficulty. It was also assumed that controllers' subjective estimates of shift difficulty would be higher for high TD shifts than for low TD shifts. While ratings of shift difficulty were found to increase as a function of traffic density, surprisingly, state anxiety was lower on high traffic density shifts than on low TD shifts. Thus, Hypothesis 4, which predicted higher A-State levels during high TD, was not supported nor was Hypothesis 5, which predicted that high A-Trait ATC's would show greater increases in A-State from low to high TD shifts. Contrary to this expectation, high A-Trait controllers were significantly lower in A-State during high TD periods than in periods of low traffic density.

The unexpected finding that A-State was lower on high TD shifts may be interpreted in two ways. First, it was possible that higher traffic density increased the controllers' involvement in their work,

especially for the high A-Trait controllers. It has been previously reported that high A-Trait persons experienced low levels of state anxiety on tasks that required their full involvement and on which they performed in a satisfactory manner (Spielberger, 1969). An alternative explanation is that the controllers tended to deny feelings of anxiety under more stressful conditions. Smith (1974) has reported that FAA controllers have strong idealized self images and take great pride in their ability to persevere under the most demanding conditions.

It should be noted that even the highest TD work shifts in the present study involved only low to moderate air traffic as compared to busy airports such as O'Hare, Kennedy, and Atlanta. Therefore, it would seem reasonable to expect that the controllers' state anxiety would increase during traffic density periods that were more intense than those experienced during the course of this study. If this were the case, there would be an inverted U-shaped curvilinear relationship between TD and A-State in which high and low levels of TD evoked higher levels of state anxiety than moderate TD.

The air traffic controllers in the present study were found to be generally low in trait anxiety, and increases in state anxiety were greater on difficult shifts for controllers who were high in A-Trait. These findings suggest that additional information regarding the personality characteristics of the air traffic controller could be of assistance in selecting persons who were best qualified for this type of work. While research within the Federal Aviation Administration has

extensively employed the 16PF in developing profiles that are currently being considered in ATC selection (Karson & O'Dell, 1974; Smith, 1974), the preliminary findings for the experimental Sociopathy Scale in this study suggested that the higher scores obtained by the ATC's on this scale may indicate some degree of immaturity. However, more information is needed on the validity of this instrument before the meaning of these findings can be fully understood.

The Psychological Stress Evaluator (PSE), an electronic instrument designed to measure stress reactions from voice recordings, was used for exploratory purposes. The unobtrusive nature of the employment of this instrument made it ideal for the measurement of stress reactions as reflected in the voice quality of the controller. Unfortunately the use of the PSE in this study was frustrated by a host of methodological difficulties. First, the potential subject pool for voice analysis in this study was greatly reduced by the necessity of limiting the data to the Tyndall AFB radar approach control center. This was the only facility where detailed indexing was routinely available to permit locating specific voice messages on the regular recorded communication files. Second, the quality of the tape recordings that were available was frequently poor with background noises that rendered many passages indistinguishable. Third, the acoustic properties of the stimulus word "zero" may not have been ideal for analysis by the Psychological Stress Evaluator. Finally, there was little agreement among the PSE raters in their scoring of the PSE charts, due perhaps in part to the use of high and low TD to establish criteria for the voice samples. Since traffic

density was found to be negatively related to STAI A-State scores, TD was not a valid independent variable for selecting the PSE voice prints that were evaluated.

In future research on the effects of stress on state anxiety in air traffic controllers, there are several methodological considerations which may be derived from the present study. Perhaps the most basic of these considerations is that it is essential to obtain the trust and confidence of ATC personnel who participate in such research. In this study, numerous informal meetings with the subjects were conducted for this purpose. Nevertheless, even with the voluntary participation of all controllers assigned to the facilities where this study was conducted, some controllers failed to complete the research materials spontaneously, as requested in the study instructions and this limited compliance reduced the amount of data that was available.

Research on the effects of stress on air traffic controllers is critical to understanding the controllers' reactions to his job, and three major conclusions can be drawn from the findings of this study that concur with prior research. First, the level of state anxiety experienced by a controller seems to depend on the controller's perceptions of the difficulties of a particular shift rather than actual traffic density. Second, state anxiety tends to increase during most work shifts, and this would seem to have important implications for the introduction of breaks and differences in the length of work shifts (Melton et al, 1973). Third, individual differences in trait anxiety are important in determining the level of state anxiety that is experienced by controllers (Smith & Melton, 1974).

While self-report measures of state anxiety are the best available methods for assessing stress reactions in ATC's these procedures are disruptive because they require controllers to stop their work to respond to questionnaires. The promise of an unobtrusive measure, such as voice analysis, lies in its ability to assess stress reactions without interrupting the controller's activities. Future research on the effects of stress on the air traffic controller might benefit from the use of self-report measures of anxiety as a criterion for assessing the validity of other state anxiety indices such as measures of voice quality or psychophysiological variables such as heart rate or blood pressure.

Chapter V

SUMMARY

The goals of this study were to examine the effects of shift difficulty and traffic density on state anxiety for United States Air Force air traffic controllers. On the basis of prior research findings with the Federal Aviation Administration ATC's and Spielberger's State-Trait Anxiety Theory, it was predicted that, state anxiety would increase over time within work shifts, that difficult work shifts would evoke higher levels of state anxiety than easy shifts, and that increases in A-State would be greater for high A-Trait ATC's than for controllers who were low in A-Trait. In addition, traffic density was expected to be positively related to state anxiety.

Air traffic controllers estimated the difficulty of work shifts by recording their estimates of shift difficulty on a six-point Likert scale. ATC's also indicated their emotional reactions to these work periods by responding to the State-Trait Anxiety Inventory (STAI) A-State scale, and the Psychological Stress Evaluator (PSE), an electronic instrument designed to measure stress reactions from voice recordings, was employed as an unobtrusive measure of state anxiety. Supervisory personnel recorded the number of aircraft handled (traffic density: TD) for these work periods.

The STAI A-State and A-Trait scores of USAF ATC's were found to be similar to the anxiety scores previously reported for Federal Aviation

Administration (FAA) controllers. Consistent with the FAA studies, state anxiety was found to increase over time on day and swing shifts in the present study. However, A-State levels were essentially stable during the mid shift. The lack of fluctuation of A-State levels during the mid shift seemed to be due to the very low TD during that shift period.

As predicted from FAA studies, "hard" shifts were found to evoke higher A-State levels than "easy" shifts, and increases in A-State from easy to hard shifts were greater for high A-Trait ATC's. While estimates of shift difficulty were higher for high TD shifts, surprisingly, low traffic density shifts were found to evoke higher A-State levels than high TD shifts. Methodological difficulties rendered the data on state anxiety as assessed from voice prints to be inconclusive.

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APPENDICES

APPENDIX A

TEST INSTRUMENTS

SELF-EVALUATION QUESTIONNAIRE

Developed by C. D. Spielberger, R. L. Gorsuch and R. Lushene

STAI FORM X-1

NAME ______________________________ DATE ______________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *feel* right now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I am regretful	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel rested	1	2	3	4
9. I feel anxious	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel "high strung"	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel over-excited and "rattled"	1	2	3	4
19. I feel joyful	1	2	3	4
20. I feel pleasant	1	2	3	4

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577 College Avenue, Palo Alto, California 94306

Modified STAI A-State Scale

DATE____________________

____
STUDY IDENTIFICATION NUMBER EXACT TIME____________________

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you felt during the half of the work shift that you have just completed.

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not At All	Somewhat	Moderately So	Very Much So
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I am regretful	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes.	1	2	3	4
8. I feel rested	1	2	3	4
9. I feel anxious	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel "high strung"	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel over-excited and rattled	1	2	3	4
19. I feel joyful	1	2	3	4
20. I feel pleasant	1	2	3	4

SELF-EVALUATION QUESTIONNAIRE

STAI FORM X-2

NAME ______________________________ DATE ______________

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I tire quickly	1	2	3	4
23. I feel like crying	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I am losing out on things because I can't make up my mind soon enough	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I am inclined to take things hard	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I try to avoid facing a crisis or difficulty	1	2	3	4
35. I feel blue	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

Shift Difficulty Scale

DATE: ____________________

____
STUDY IDENTIFICATION NUMBER

EXACT TIME: ______________

DIRECTIONS: A scale is provided below for you to indicate the difficulty of that half of the work shift that you have just completed.

1	2	3	4	5	6
Very Easy	Easy	Neither Difficut nor Easy		Difficult	Very Difficult

Social Attitude Scale

Directions: This scale consists of 35 statements. Read each statement carefully and decide how you feel about it. If you agree with a statement, or feel that it is true about you, circle the letter T on your answer sheet. If you disagree with a statement, or feel that it is false about you, circle the letter F on your answer sheet. Please respond to all of the items. If you are undecided about any item, indicate true or false according to the way you feel most of the time.

	True	False
1. I do not read every editorial in the newspaper everyday.....	T	F
2. I am against giving money to beggars......................	T	F
3. Sometimes at elections, I vote for men about whom I know very little..	T	F
4. I don't blame anyone for trying to grab everything he can in this world	T	F
5. I like to know some important people because it makes me feel important	T	F
6. Most people make friends because friends are likely to be useful to them..	T	F
7. I would rather win than lose in a game	T	F
8. When I get bored, I like to stir up some excitement	T	F
9. I do not like everyone I know	T	F
10. Sometimes I find it hard to stick up for my rights because I am so reserved	T	F
11. I wish I were not so shy	T	F
12. I get angry sometimes	T	F
13. At times, I feel like swearing	T	F
14. Sometimes when I am not feeling well, I am cross	T	F
15. I do not dread seeing a doctor about a sickness or injury...	T	F
16. Sometimes my voice leaves me or changes even though.........	T	F

17. I am not bothered by a great deal of belching of gas from my stomach .... T F

18. Criticism or scolding hurts me terribly .... T F

19. Once in a while, I think of things too bad to talk about.. T F

20. I have very few quarrels with members of my family........ T F

21. My table manners are not quite as good at home as when I am out in company .... T F

22. At times, I have very much wanted to leave home .... T F

23. I do not like to see women smoke .... T F

24. It makes me impatient to have people ask my advice or otherwise interrupt me when I am working on something important .... T F

25. Once in a while, I put off until tomorrow what I ought to do today .... T F

26. When someone does me wrong, I feel I should pay him back if I can, just for the principle of the thing .... T F

27. Once in a while, I laugh at a dirty joke .... T F

28. I like to go to parties and other affairs where there is lots of loud fun .... T F

29. I love to go to dances .... T F

30. I do not mind being made fun of .... T F

31. It makes me uncomfortable to put on a stunt at a party even when others are doing the same thing .... T F

32. I gossip a little at times .... T F

33. If I could get into a movie without paying and be sure I was not seen, I would probably do it .... T F

34. I frequently have to fight against showing that I am bashful.T F

35. I do not always tell the truth .... T F

APPENDIX B

SAMPLE VOICE PRINT

CHART NO.5009

APPENDIX C

INFORMATION SHEET AND INSTRUCTIONS

INFORMATION SHEET
AIR TRAFFIC CONTROL STUDY

Introduction:

We would like you to participate in a study on psychological stress factors in Air Traffic Control work. This study is supported by the Office of the Air Force Surgeon General, the Air Force Institute of Technology and the University of South Florida.

This research will be of great assistance in identifying and monitoring factors that add to the difficulty of your job. In order for our results to be most meaningful, we must obtain a large number of participants. Therefore, your participation in this study is very important.

If you are willing to take part, you will be asked to complete several short forms which will help to describe Air Force ATC's. In addition, we would like for you to estimate the difficulty of your work shifts by completing a form at the middle and at the end of each work shift. We would also like you to fill out several brief questionnaires concerning your reaction to each half of the work shifts. Finally, regularly recorded air traffic control communications will be studied to examine stress in the voice.

All information shared by participants will be treated with confidentiality and will be used only in the context of this research. Please ask any questions that you may have regarding the study, and understand that taking part is voluntary. If you agree to participate, you may withdraw at any time.

Informed Consent:

It has been explained to me that an official Air Force study is being conducted on psychological stress factors in air traffic control work. Further, I understand that as a voluntary participant in this research, I will be asked to complete several forms which will be used to describe Air Force ATC's. In addition, I will be asked to estimate the difficulty of work shifts and to fill out several brief questionnaires regarding my reactions to work shifts. I also understand that regularly recorded ATC communications will be studied to examine stress in the voice. Finally, it has been explained that all of the information that I contribute to the study will be treated with confidentiality and used only in the context of this research project.

I agree to participate in this study, knowing that I can withdraw at any time.

______________	______________________	_________________________
Date	Printed Name	Signature

STUDY IDENTIFICATION NUMBER

It is very important that the forms and questionnaires which you will be asked to complete are responded to honestly and candidly. This study has been designed to allow you to feel free to respond genuinely.

First, all of the results of this study will be reported as group averages. Neither the names of the participants nor the specific information they share will be revealed.

Second, to assure the confidentiality of the information that is contributed, each participant will be assigned a STUDY IDENTIFICATION NUMBER. This number will allow for the administrative processing of data and the individual assigned each number will be known only to the principal investigator of this study and the research project staff at the University of South Florida and will not be available to any other personnel.

Please use your Study Identification Number on each form that you complete. Please keep this sheet so you will have a record of your number.

YOUR STUDY IDENTIFICATION NUMBER IS:

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APPENDIX D

EXPERIMENTAL SOCIOPATHY SCALE AND MMPI LIE SCALE RESULTS

The Spielberger, O'Hagan, Kling (1977) Experimental Sociopathy Scale (SPY Scale)[1] was administered at Tyndall AFB. Results indicated that scores were relatively high (mean 13.5, standard deviation 2.7) compared to norms for young male prisoners (age 21-26 years) who had a mean score of 11.51 and standard deviation of 2.8 (Spielberger, et. al., 1977).

The Lie Scale of the Minnesota Multiphasic Personality Inventory (MMPI) was also administered at Tyndall AFB. Subjects' mean scores (3.9, standard deviation 1.8) corresponded to an MMPI t score of 52, and were essentially within normal limits. These results indicated that normal levels of defensiveness were encountered (Dahlstrom, Welsh & Dahlstrom, 1973). In combination, SPY and MMPI Lie Scale Findings suggest that the ATC population at Tyndall AFB scored higher in psychometric sociopathic qualities than a population of convicts of similar age. In addition, these controllers appeared to respond to these scales without deliberate or intentional efforts to evade answering the tests frankly and honestly.

---

[1]This version of the SPY Scale contained only 19 items, as a typographical error invalidated one item on the test form.

APPENDIX E

RAW DATA

In this appendix, the raw data is presented for subjects at MacDill and Tyndall AFBs. These data consist of age, ATC experience, STAI A-Trait scores and STAI A-State scores for easy and hard shifts. In addition, Tyndall RAPCON ATCs data includes experimental Sociopathy Scale (SPY) scores, MMPI Lie Scale scores and traffic density (TD) counts, and Shift Difficulty Scale (SDS) scores. Finally, ratings by the three PSE raters are presented.

MacDill AFB Data

	Subject No.	Age	ATC Experience	A-Trait	A-State			
					1st Easy	Easy	1st Hard	Hard
Tower								
	1	19	-1	30				
	2	30	5.5	29				
	4	29	.1	41				
	6	31	10.3	24				
	7	23	.1	23				
	8	26	6.8	24				
	9	25	.5	41				
	10	22	.9	32	35	35	33	32
	11	39	12.3	20				
	12	26	4.7	40	21	26.5	24	23.5
	13	38	19	46	50	49.8	49	47
	14	24	.3	49	48	49	48	49
	15	41	22.1	33	35	32.4	33	33
	16	20	1.3	35	26	25	37	33
	17	22	2.8	36	27	34	34	35
	18	33	15	34	23	281.	31	32.5
	19	20	2	35	32	32	43	44.5
	20	25	4.5	25	21	28	36	38
	21	21	1.4	29	27	27	25	25
	22	27	8.2	22	21	21.5	33	33
	23	25	3.4	24	27	27	27	27
	24	27	1	31	34	33.3	35	41.5
Radar	25	35	5.5	23	23	27.6	34	34
	26	21	.8	25	26	31.8	30	30
	27	29	4.1	22	32	31.3	52	52
	28	23	.1	21	28	35.7	26	27
	29	23	1.5	30	29	27	28	28
	30	21	2	24	20	26.4	59	59
	31	37	19	24	20	20	36	36
	32	20	.8	21	28	28	29	28
	33	25	2.3	30	29	29	33	30
	34	34	5	30	21	27.7	31	30
	35	38	12	35	27	26.2	32	32
	36	21	1.5	32	26	26	30	30
	37	21	.9	34	46	39.6	40	40
	38	24	2.8	36	25	22.8	26	26
	39	38	20.2	22	27	27	35	35
	40	19	.7	32	31	33	37	37.5
	41	21	1.5	43	29	29.5	31	31

42	27	2	38	36	36	41	39
43	19	.5	39	43	43	34	34
45	21	.11	27				
46	35	7.5	27	24	24	27	27
48	22	.5	29				
50	25	4.1	24				
51	42	2.8	21				
52	19	1.6	31				
53	26	1.6	31				

Tyndall AFB Data

STAI A-State Scores

							Shift Difficulty				Work Shifts: Day			Work Shifts: Swing			Work Shifts: Mid			TD, SDS and Corresponding A-State Scores					
Subject No.	STAI A-Trait	Age	ATC Experience	SPY Scale	Lie Scale	1st Score in Study	1st Easy	Easy Average	1st Hard	Hard Average	Pre Shift	1st Half Shift	2nd Half Shift	Pre Shift	1st Half Shift	2nd Half Shift	Pre Shift	1st Half Shift	2nd Half Shift	Lowest TD	STAI A-State	SDS	Highest TD	STAI A-State	SDS
RAPCON																									
1	34	37	6.1	15	4	41	26	26	41	39	30	30	38	22	22	27	28	36	39	0	39	5	96	22	2
2	30	30	10.3	15	4	61	37	37	61	52				36	44	51				2	37	2	96	44	4
3	33	22	4.1	11	2	42	31	35.5	42	38.5	45	40	40	36	42	43	29	29	30	36	35	3.5	132	42	2
4	25	26	7.7	16	8	26	20	22.5	26	24				24	26	20				36	20	1	132	22	4
6	31	38	19.5	16	5	48	34	35	50	44.5	30	34	36	45	33	42				34	42	4	132	39	5
7	31	29	.5	14	3	38	38	38	37	37										72	38	3	111	37	5
8	41	25	1	15	4	41	41	41	47	47										72	41	3	111	47	5
9	48	24	.6	12	4	60	20	20	42	36										72	60	4	132	30	2

10	37	29	.5	13	3	29																			
11	28	30	.8	15	7	51																			
12	52	30	.6	11	4	44																			
13	32	37	6	14	1	55	36	36	55	56.5				38	55	58				36	58	5	96	36	2
14	27					36	31	26	26	31										72	36	3	109	26	5
15	31	28	2	13	3	30					31	30	31	25	30	32	27	29	28						
16	33	32	10.3	16	6	43	43	44	39	41.2	42	43	39	34	43	48				34	48	2	132	45	3.5
17	30	26	5	13	4	26	26	26.3	29	29.5	26	27	30				31	27	26	0	26	1	90	29	3.5
18	26	33	15.5	12	3	23	20	22	23	23										75	20	1	90	23	1
19	32	30	.8	12	3	32	32	32	32	32										80	32	1	132	32	3
21	26	36	7	16	5	24	24	24	43	43										33	43	5	111	25	2
22	32	29	9.8	14	5	34	32	32.7	34	41.5	28	34	42	29	34	32				16	32	2	111	43	5
23	26	31	1.2	11	2	34																			
24	37	28	9	17	3	51																			
25	28	35	5.8	13	3	35	30	32	57	57	25	35	57	27	30	34				22	30	2	111	32	5
26	37	30	.3	12	4	45	28	31	45	45										75	28	2	132	34	2
27	54	38	5	8	2	50	48	48	60	59										39	48	3	109	50	4
28	36	32	.3	12	3	27	27	27	27	27										75	27	1	80	27	4
29	33	24	.7	18	5	34	48	46.5	34	37				42	48	45				16	45	3.5	109	34	6
32	26	36	6	17	4	32																			
33	35	27	5.2	15	3	29																			
34	22	27	4.5	9	2	33	20	20	33	36.5				20	20	20				21	20	1	96	20	1
35	37	27	5.2	16	3	43	43	43	56	56	41	43	43							22	43	2	81	43	3.5
36	25	25	4.8	15	3	35	35	33	43	43	24	35	28							2	34	3.5	96	35	3.5
37	38	40	20	12	5	58	25	25	58	58	26	58	29							22	29	2	96	24	3.5
38	32	31	7.2	16	8	31	31	26.5	22	22										22	22	1	81	22	4
39	38	38	13	13	2	62																			
40	33	26	4.8	11	3	33					36	33	33	29	28	25									
41	28	26	6.1	15	3	26	26	27	31	31				32	31	29				21	29	1	96	37	1
42	23	29	10.9	19	11	20					22	23	22												
43	41	25	6.3	13	2	24	43	24	24	52	39	24	52				44	41	42	0	44	3	81	24	2
44	34	24	.2	7	3	40																			

45	28	29	.5	11	2	29																			
Tower																									
63	27	28	1.1	14	6	31	31	30	35	35										41	33	5	750	29	2
64	32	24	5.3	17	5	44	28	25	44	44	26	28	31							25	44	6	204	28	3
65	40	43	8.5	7	2	45	43	39.7	40	40.5	42	39	40	40	41	40				24	39	2	750	40	4
66	24	24	5.3	12	4	32	32	34.3	34	34.5	29	32	37	33	33	33	33	33	35	0	35	1	696	32	1
67	33	28	3.8	12	2	30					29	30	31				32	34	33						
68	22	23	.5	17	4	30																			
69	32	28	6.1	14	5	26																			
70	23	38	1.5	14	5	26																			
71	35	22	.7	16	6	39																			
73	25	27	4.8	17	5	24	32	33.3	24	27.3	26	32	25				28	29	30	0	29	1	750	32	5
74	34	33	13.9	16	5	36	37	40.5	48	52.5	27	36	48				41	37	41	0	37	1	750	42	5
75	32	25	3.3	11	2	39	39	43.3	36	36				39	39	43				1	43	1	204	36	3
76	38	26	5.5	11	5	29					25	29	26												
77	24	38	19.1	11	5	30	21	21	30	27.5	27	29	26							215	21	2	750	28	4
78	25	34	4.8	11	3	28								34	28	42									

Judges Ratings for PSE Data

Subject	STAI A-Trait Score	Voice Print Sequence*						Rater 1						Rater 2						Rater 3					
A	32	H	L	H	L	L	H	H	L	L	L	H	H	L	H	L	H	H	L	H	L	L	L	H	H
B	25	L	H	H	H	L	L	L	H	L	L	H	H	L	H	H	L	L	H	L	H	L	L	H	H
C	25	H	L	L	H	H	L	L	H	H	H	L	L	H	H	L	H	L	L	L	H	H	L	H	L
D	31	L	H	L	L	H	H	L	H	L	L	H	H	H	H	H	L	L	L	L	H	L	L	H	H
E	54	H	L	L	L	H	H	L	H	H	H	L	L	H	H	L	L	H	L	H	H	H	L	L	L
F	31	L	L	H	H	L	H	L	H	H	L	L	H	L	L	H	H	L	H	L	H	L	H	H	L
G	23	H	H	H	L	L	L	L	H	H	H	L	L	L	L	H	H	L	H	H	H	L	L	L	H
H	32	L	H	H	L	H	L	H	L	L	H	H	L	H	L	L	H	H	L	H	L	L	H	H	L
I	26	L	H	L	H	H	L	L	L	H	L	H	H	L	L	H	L	H	H	L	L	H	H	H	L
J	28	H	L	L	H	L	H	H	H	L	L	L	H	L	H	H	L	L	H	H	H	L	L	L	H
K	32	H	L	H	H	L	L	H	L	L	H	L	H	L	L	H	L	H	H	H	H	L	L	L	H
L	37	L	H	L	H	L	H	H	L	H	L	H	L	L	H	L	H	H	L	H	L	L	H	H	L

H	37	H	H	L	L	H	L	H	H	H	L	L	L	L	H	L	L	H	H	L	H	L	L	H	H
H	33	H	L	L	L	H	H	L	H	L	L	H	H	L	H	L	L	H	H	L	H	L	L	H	H

* H refers to High Stress, L indicates Low Stress